



# FCS Technology Investigation Overview and Status

ITT – Advanced Engineering & Sciences/Glen Dyer;  
QinetiQ/Phil Platt

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# Briefing Outline

- Objective and Work Plan
- Technology Pre-Screening Activities and Results
- Stakeholder Feedback to Pre-Screening Recommendations
- Technology Investigation Activities
- Planned Activities

# Technology Investigation Objective & Work Plan

- Objective - investigate potential communications technologies to support the long-term mobile communication operating concept.
  - Consider satellite and terrestrial based infrastructure
- Three planned work phases
  - Task 3.1 – Technology Pre-Screening: Pre-screen potential technologies and detail their capabilities, projected maturity, and potential applicability
  - Task 3.2 – Technology Investigations: Identify a set of technologies that will meet the communications requirements
  - Task 3.3 – Technology Simulation: Simulate technology to verify compliance with requirements

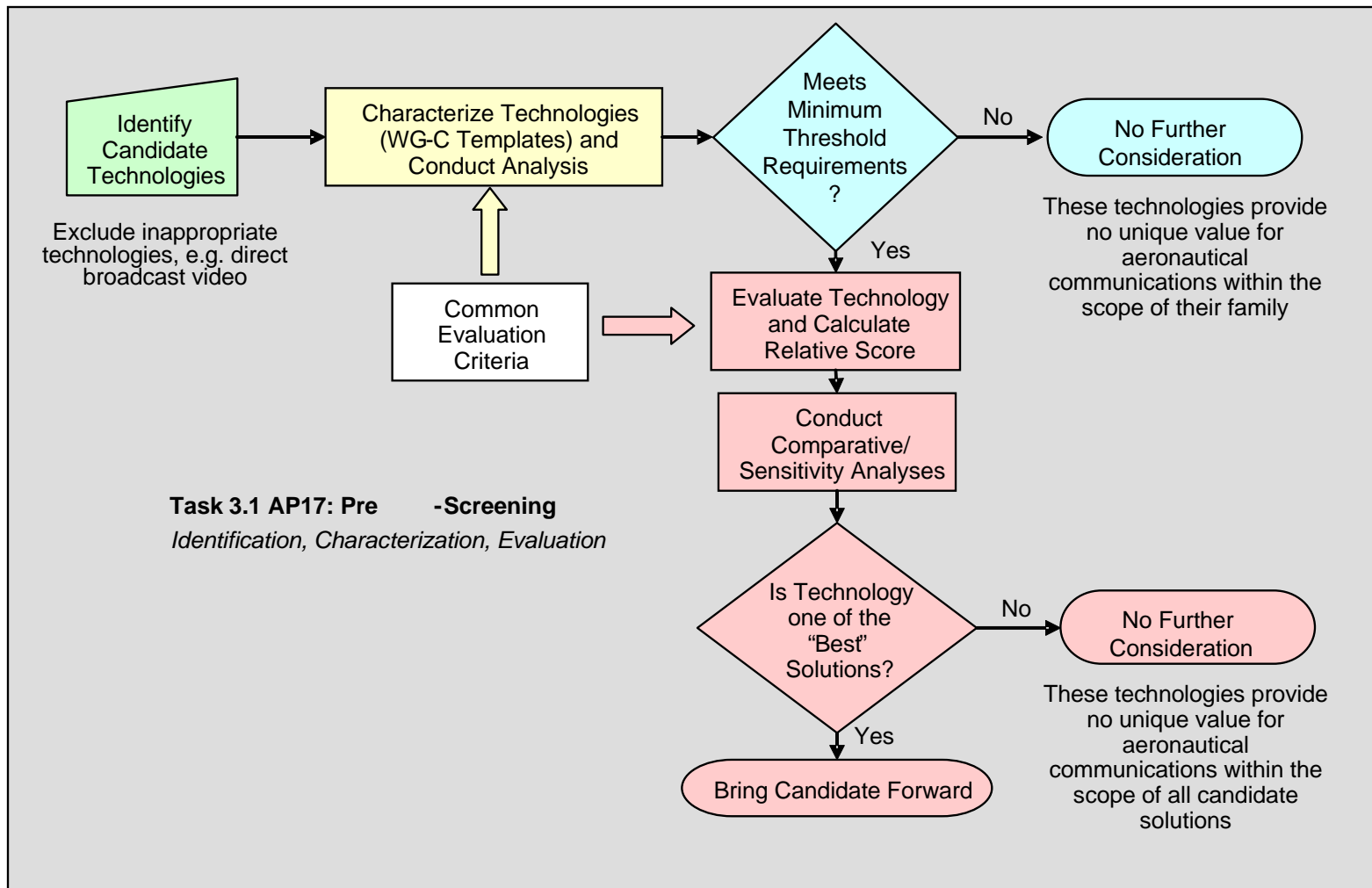
# Technology Pre-Screening Activities

- Completed Activities Included:
  - Developed inventory of potentially applicable technologies
  - Developed evaluation methodology, evaluation criteria and evaluation metrics
  - Developed recommendations for the use of aviation spectrum
  - Evaluated technologies and developed recommendations

# Pre-Screening Activities - Technology Inventory

Technology Family	Candidates
<b>Cellular Telephony Derivatives</b>	TDMA (IS-136), CDMA (IS-95A), CDMAone (IS-95B), CDMA2000 1xRTT, W-CDMA (US)/UMTS FDD (Europe), TD-CDMA (US)/UMTS TDD (Europe), CDMA2000 3x, CDMA2000 1xEV, GSM/GPRS/EDGE, TD-SCDMA, DECT
<b>IEEE 802 Wireless Derivatives</b>	IEEE 802.11, IEEE 802.15, IEEE 802.16, IEEE 802.20, ETSI HIPERLAN, ETSI HIPERMAN
<b>Public Safety and Specialized Mobile Radio</b>	APCO P25 Phase 1, APCO P25 Phase 2, TETRA Release 1, TETRAPOL, IDRA, IDEN, EDACS, APCO P34, TETRA Release 2 (TAPS), TETRA Release 2 (TEDS), Project MESA
<b>Satellite and Other Over Horizon Communication</b>	SDLS, Connexion by Boeing, Swift Broadband (Aero B-GAN), Iridium, GlobalStar, Thuraya, Integrated Global Surveillance and Guidance System (IGSAGS), HF Data Link
<b>Custom Narrowband VHF Solutions</b>	VDL Mode 2, VDL Mode 3, VDL Mode 3 w/SAIC, VDL Mode E, VDL Mode 4, E-TDMA
<b>Custom Broadband</b>	ADL, Flash-OFDM, UAT, Mode-S, B-VHF (MC-CDMA)
<b>Military</b>	Link 16, SINCGARS, EPLRS, HAVEQUICK, JTRS
<b>Other</b>	APC Phone (Airphone, AirCell, SkyWay)

# Pre-Screening Activities – Evaluation Methodology



# Pre-Screening Recommendations

- Major finding and recommendations included:
  - There is no one technology that meets all of aviations needs for all phases of flight
  - At the 2007 WRC, ICAO should:
    - Pursue AM(R)S allocation in DME band
    - Pursue AM(R)S allocation for 5091 to 5150 MHz band
  - Solutions to aviation A/G communications congestion will necessarily be one of four forms
    - A technology that uses the VHF spectrum more efficiently
    - A technology that can co-exist in the DME band
    - A technology that can co-exist in the MLS band
    - Satellite technologies with allocated AMS(R)S spectrum

# Pre-Screening Recommendations

## **Eurocontrol/QinetiQ**

- Evolution of existing aeronautical systems or concepts.
  - XDL-3, XDL-4, ETDMA
- Terrestrial Systems
  - B-VHF, WCDMA, P34.
- Satellite Systems
  - INMARSAT SwiftBroadband
  - New satellite System(s)
- Airport / Surface systems
  - 802 derivatives .11x, .16 and .20
  - Airport Data Link

## **NASA/ITT**

- Technologies applicable for provision of comms over enroute, terminal and surface airspace domains
  - Primary: VDL3/E in VHF Band; P34 in L-Band, VDL-3 in L-Band, B-VHF in L-Band
  - Secondary: WCDMA (L-Band)
- Technologies applicable for provision of communications over specific airspace domains
  - Oceanic: INMARSAT-4 (Swift Broadband); Iridium in AMS(R)S
  - Surface: IEEE 802.16 in (5091-5150 MHz)



# Stakeholder Feedback

## ICAO ACP

- Genesis of evaluation criteria is not clear. Evaluation criterion traceable to the COCR is required
- The evaluation process is understood and endorsed
- However:
  - Prescreening objectives were too broad. What is needed is a data link system. It is expected that 8.33 kHz analog voice will meet voice needs for the foreseeable future.
  - Focus on a data-only system (complement existing voice capabilities)
  - Repeat the prescreening process
- Note that the new system will augment existing systems, not immediately replace them

# Technology Investigation Activities - ITT

- This phase of the technology assessment has two major objectives
  - Show traceability of evaluation criteria to the COCR and revisit the pre-screening
  - Investigate fundamental issues facing potential air-ground and air-air data-link solutions in specific portions of existing aviation frequency spectrum, including:
    - Spectrum sharing with aviation radio-navigation systems in L-band
    - Use of commercial satellite communications (SATCOM) bands for safety-critical services
    - System performance in the challenging propagation environment expected in the portion of C-band currently allocated to the Microwave Landing System (MLS)

# Planned Activities - ITT

- Currently planning the final phase of technology investigation activities
- It is anticipated that the work will include
  - Further detailed technology investigations
    - Culminate in recommended signal structure for utilization of L-Band
  - Conduct a measurement campaign to further characterize interference susceptibility of existing systems at L-Band

# Technology Investigation Activities – EUROCONTROL/QinetiQ

- Discussions in Air Ground Communications Focus Group
  - Initial Evaluation Criteria: difficult to agree on metrics, iterative process => can be long
  - Alternative approach: Use expert judgement on available information and build upon
  - A 2 step approach has been taken to reach a conclusion

# Planned Activities

## EUROCONTROL/QinetiQ

### ➤ Step 1

- Focus on capacity and QoS requirements from COCR
- Use results from previous assessments
- Take into account new developments
- Establish initial list of promising technologies
- Nearing completion

### ➤ Step 2

- Complete investigations with assistance of advocates of technologies
- Make recommendations for FCI

# Supplemental Slides

Background and additional detail

# Background

- ICAO ANC/11 noted:
  - Aeronautical communication infrastructure has to evolve
  - Various proposals to address this problem have been offered; none has achieved global endorsement
  - There are universally recognized benefits of harmonization and global interoperability
- Consequently, ANC/11 recommended:
  - Adopt an evolutionary approach for global interoperability
  - Investigate new terrestrial and satellite-based technologies
  - Undertake new standardization work only when system meets ATM requirements, is technically proven, consistent with the requirements for safety, cost beneficial and promotes global harmonization
- FAA and Eurocontrol embarked on a bi-lateral study (FCS) with the support of NASA; study is to provide input to the ICAO Aeronautical Communications Panel (ACP)
  - FCS goals and process are outlined in Action Plan 17 (AP-17)



# Background – FCS Activities

- FCS activities, as outlined in the AP-17 work plan, consist of both technical and business themes
  - Technical themes
    - Improvements to current systems – spectrum management techniques to relieve VHF band congestion. This work area is closed.
    - Identify the mobile communications operating concept – this is an ongoing activity. The “Communications Operating Concept and Requirements for the Future Radio System” Version 1.0 was released in March 2006.
    - **Investigate new technologies** for mobile communications – NASA is the lead organization for the US activities in this task, and has established a Technology Assessment Group through a contract to ITT
    - Identify the communications roadmap – this is an on-going activity. A draft version of this roadmap will be discussed in one of today’s presentations.
    - Investigate feasibility of airborne communication flexible architecture
    - Investigate the spectrum bands for new system
  - Business themes include creating a multi-national framework, creating industry interest and developing a business model



# Consensus Evaluation Criteria

- Technology pre-screening evaluation criteria were derived via a consensus process during 2004

**July** – ITT Synthesizes evaluation criteria from 11th ICAO Air Navigation Conference (Sept/Oct 2003) recommendations

**August** – ITT and QinetiQ work towards refining the evaluation criteria, and developing a consensus set of criteria. In parallel, the FAA RTTA team is developing a set of evaluation criteria

**September** – A mapping between the ITT and QinetiQ consensus criteria and the independently developed RTTA criteria is developed and presented to the FAA. Mapping shows substantial overlap, and highlights missing criteria in the ITT and QinetiQ set, which are adopted. Evaluation criteria are baselined, and the FAA RTTA team begins work of defining evaluation metrics

**October** – Through two rounds of FAA comments, ITT and QinetiQ replies, and then a round table discussion between ITT, NASA and the FAA RTTA team, evaluation metrics are decided and harmonized. In the process, some of the evaluation criteria are modified. An additional criteria, transition is adopted, and one criteria, COTS Leveraging, is eliminated. The evaluation criteria and metrics are placed under configuration control on October 7, 2004.

# ITT Technology Investigation Activities - Evaluation Criteria Development & Re-Screening

- The purposes of this task are to develop functional and performance evaluation criteria that are traceable to the COCR, and to select a set of technologies that can meet these requirements
- Work Activities
  - Develop a set of functional and performance evaluation criteria that are traceable to the COCR or other consensus documentation
  - Augment COCR capacity requirements to account for protocol overhead, channel contention and channel access mechanisms
  - Evaluate technologies using this set of traceable criteria

# ITT Technology Investigation Activities - L-Band

- Objectives
  - Primary : characterize the technical parameters of a good solution at L-Band
  - Secondary: develop estimate of the viability of a leased service in this band
- Work Activities
  - Propagation Analysis
    - Develop L-Band Air/Ground channel characterization
  - Interference Analysis
    - Characterize the interference environment – develop models that can be used to characterize the performance of FCS candidates
    - Characterize the susceptibility of existing systems – determine susceptibility of existing systems to interfering sources
  - Physical layer simulation development
    - Develop physical layer simulations and estimate the best waveform characteristics for the expected propagation and interference environment
  - Business Case Development
    - Develop recommended technical parameters of a ground L-Band infrastructure and then determine if the business case can close.

# ITT Technology Investigation Activities - Satellite Studies

- The purpose of this task is to assess the viability of using existing commercial satellite systems with AMS(R)S allocations to provision the communications services that are detailed in the COCR
- Work Activities
  - A: Provide comparative analysis of availability of the identified commercial satellite architecture(s) and the current (VHF) terrestrial communication architecture for provision of aeronautical mobile services
  - B: Evaluate which COCR services could be provisioned by existing commercial satellite systems with AMS(R)S allocations
    - Include Iridium-only, Inmarsat-only, and a combined Iridium/Inmarsat architecture
    - For those services that can be provisioned, describe how, and evaluate avionics architecture requirements and certification issues
  - C: If no COCR services can be provisioned by existing commercial satellite systems with AMS(R)S allocations, define and describe a SATCOM architecture (perhaps augmented by terrestrial infrastructure) that can meet COCR service requirements
    - Indicate other services that might be provisioned via commercial satellite systems (SWIM applications, weather, others)

# ITT Technology Investigation Activities - C-Band

- The purposes of this activity are to model the C-Band surface (airport) propagation environment including the effects of multipath fading, and to assess the performance of a commercial C-Band technology
- Work Activities
  - Since 802.16e was recommended in the first phase of the FCS Technology Assessment activities, it was selected for analysis
  - This task will develop a detailed simulation of 802.16e, implement the Ohio University airport channel models, and assess system performance